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Hamzeh

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(54) **COMMUNICATION NETWORKS INCLUDING MULTI-PURPOSE SHARED COMMUNICATION MEDIUMS, AND ASSOCIATED METHODS**

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(51) **Int. Cl.**

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H04L 12/46	(2006.01)
H04L 12/709	(2013.01)
H04L 12/801	(2013.01)
H04W 76/16	(2018.01)
H04W 88/16	(2009.01)
H04W 92/02	(2009.01)

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CPC ***H04L 47/41*** (2013.01); ***H04L 12/46*** (2013.01); ***H04L 45/245*** (2013.01); ***H04L 47/15*** (2013.01); ***H04W 76/16*** (2018.02); ***H04W 88/16*** (2013.01); *H04W 92/02* (2013.01)

(58) **Field of Classification Search**

CPC H04W 88/16; H04W 76/16; H04W 92/02; H04W 16/14; H04L 45/245; H04L 12/2898; H04L 47/15; H04L 12/2863; H04L 12/2867; H04L 12/66; H04L 12/46; H04L 12/2869; H04L 47/41

See application file for complete search history.

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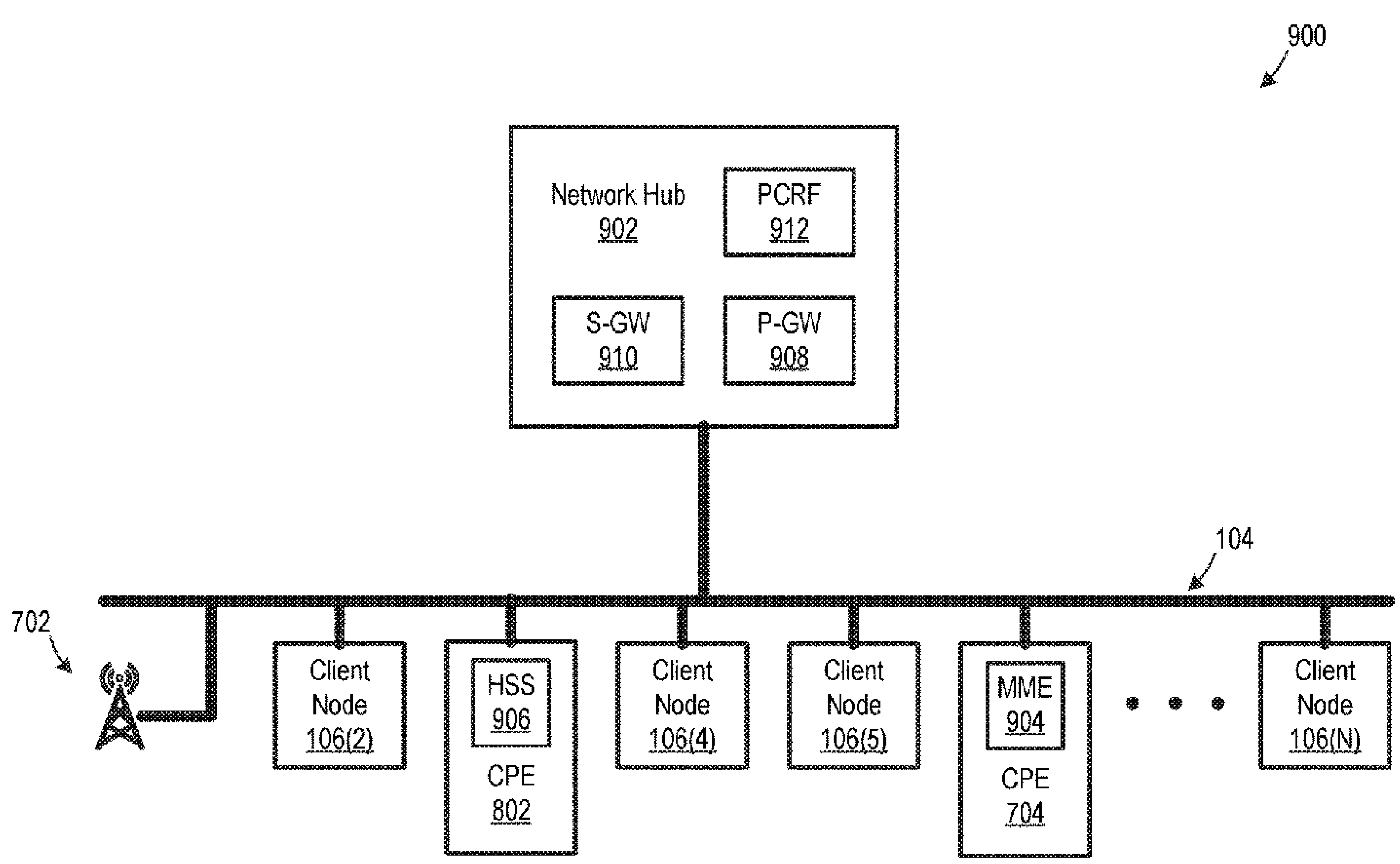
(57) **ABSTRACT**

A method for transmitting data in a communication network including a shared communication medium includes (a) transmitting local data between a first client node and a second client node according to a first data protocol, using a first shared communication medium, and (b) transmitting remote data between the first client node and a network hub according to a second data protocol different from the first data protocol, using at least the first shared communication medium.

18 Claims, 15 Drawing Sheets



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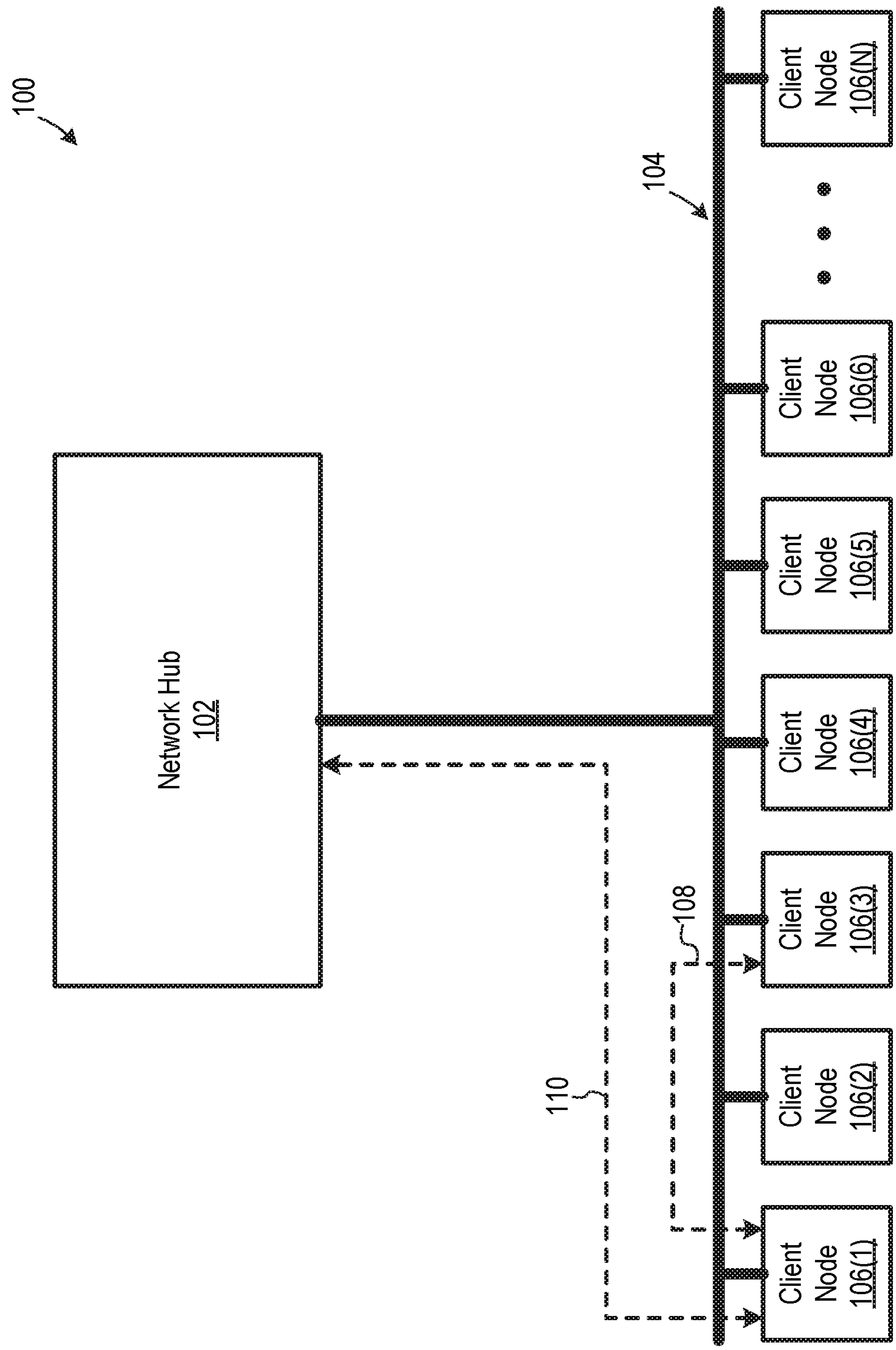
100
Network Hub
102
104
108
110
Client
Node
106(1)
Client
Node
106(2)
Client
Node
106(3)
Client
Node
106(4)
Client
Node
106(5)
Client
Node
106(6)
Client
Node
106(N)

FIG. 1

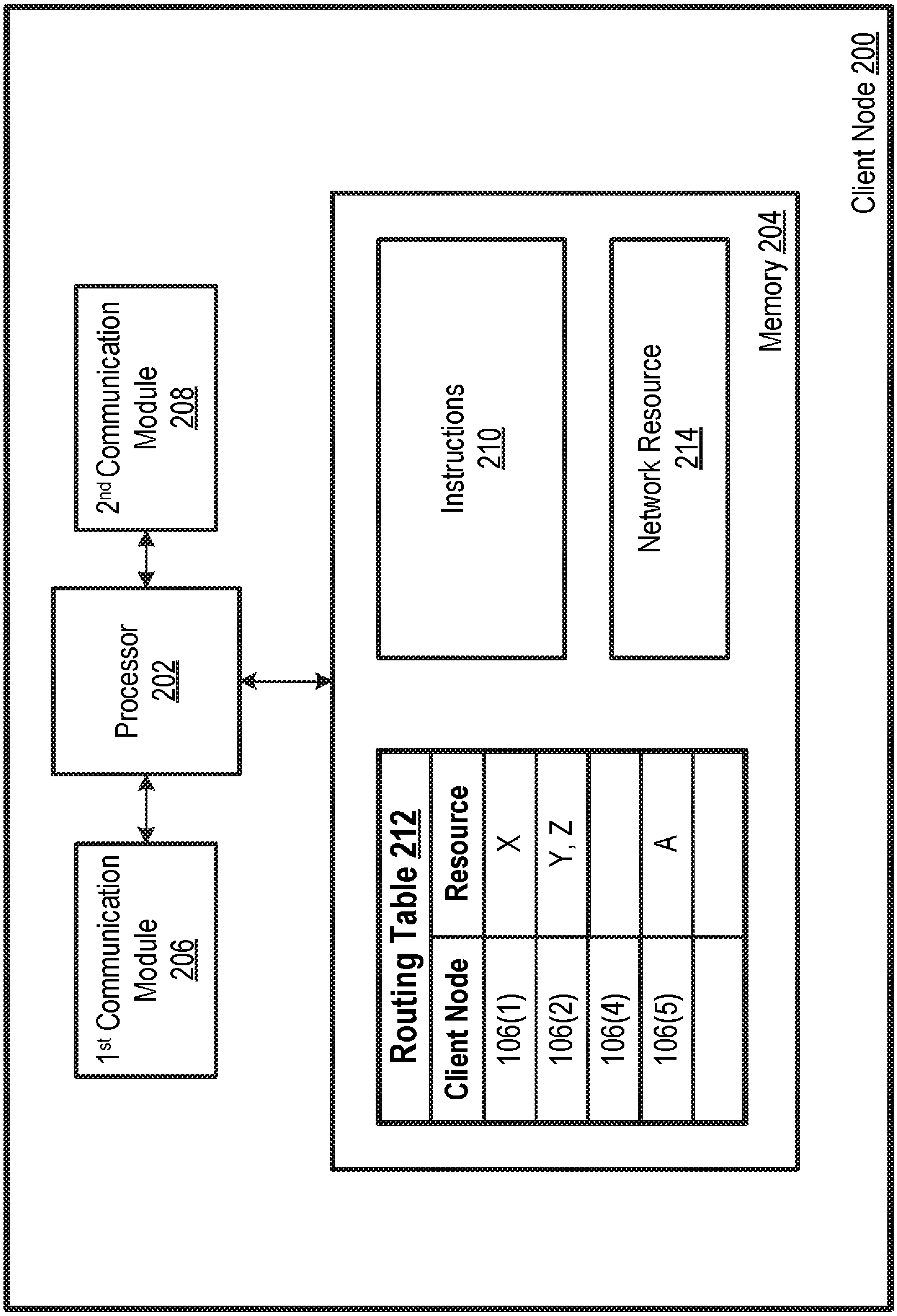
Client Node 200
Processor 202
1st Communication Module 206
2nd Communication Module 208
Memory 204
Instructions 210
Network Resource 214
Routing Table 212
Client Node
Resource
106(1)
X
106(2)
Y, Z
106(4)
106(5)
A

FIG. 2

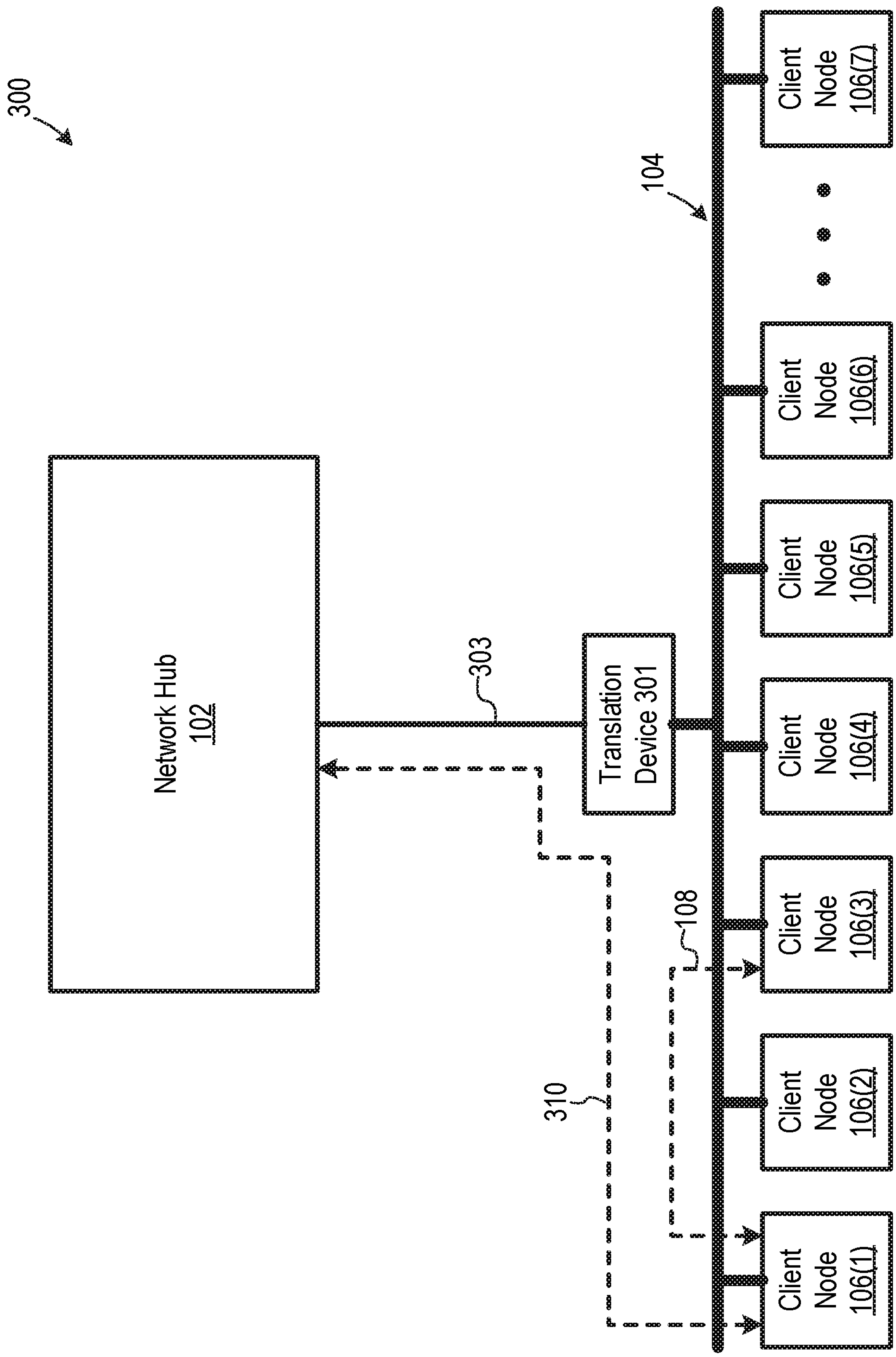
300
Network Hub
102
303
Translation
Device 301
104
108
310
Client
Node
106(1)
Client
Node
106(2)
Client
Node
106(3)
Client
Node
106(4)
Client
Node
106(5)
Client
Node
106(6)
Client
Node
106(7)

FIG. 3

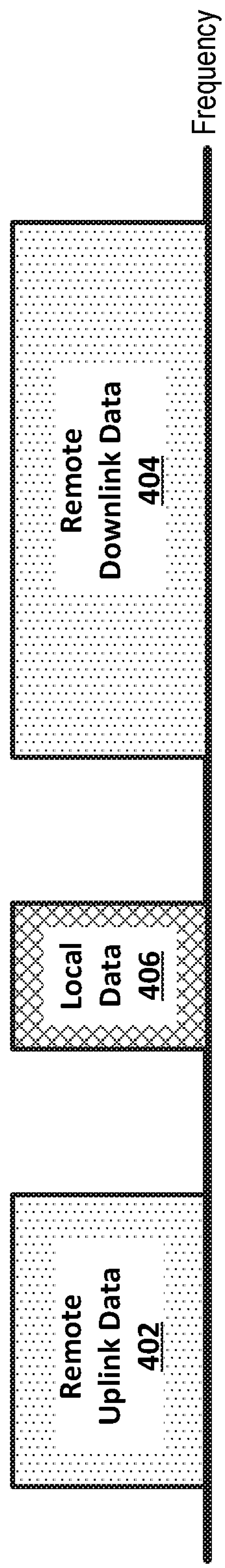
Frequency
Remote Downlink Data 404
Local Data 406
Remote Uplink Data 402

FIG. 4

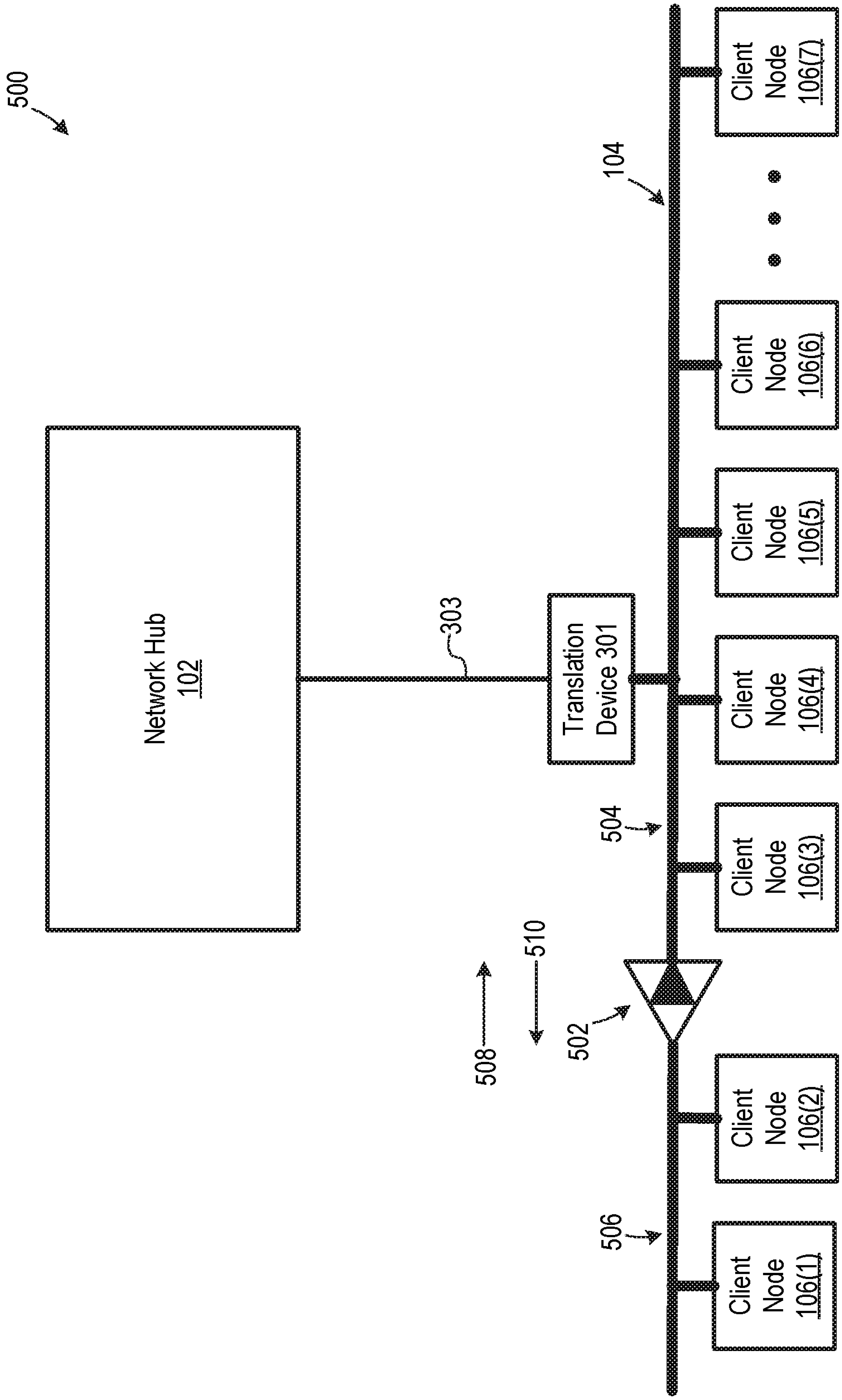
500
Network Hub 102
303
Translation Device 301
104
Client Node 106(7)
Client Node 106(6)
Client Node 106(5)
Client Node 106(4)
Client Node 106(3)
Client Node 106(2)
Client Node 106(1)
504
502
506
508
510

FIG. 5

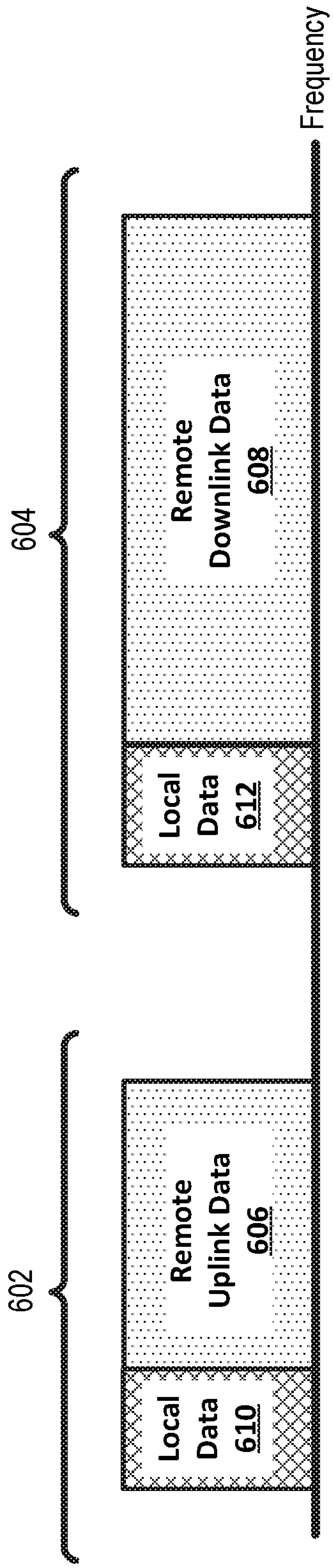
Frequency
604
602
Remote
Downlink Data
608
Local
Data
612
Remote
Uplink Data
606
Local
Data
610

FIG. 6

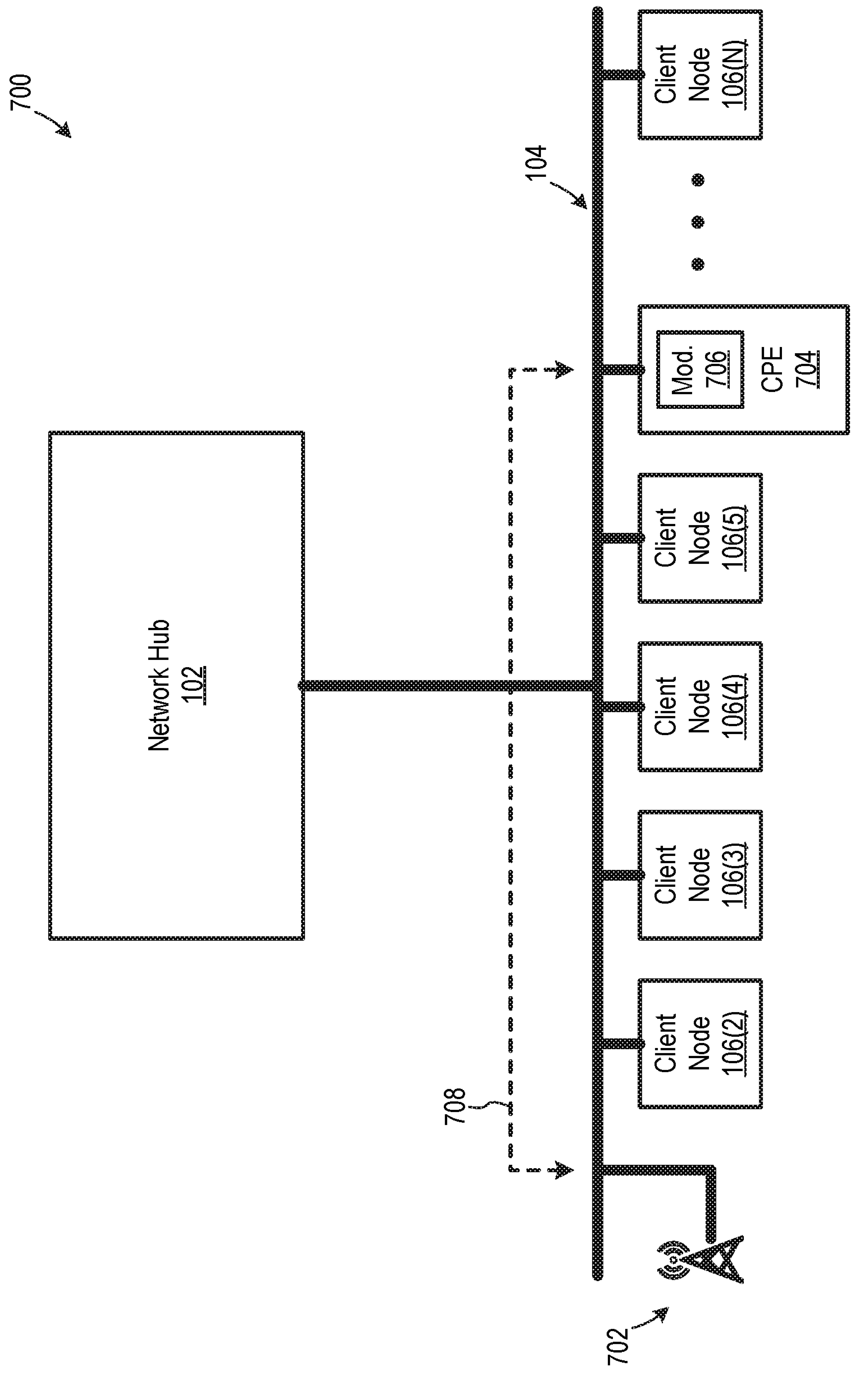
700
Network Hub
102
104
Client
Node
106(N)
Mod.
706
CPE
704
Client
Node
106(5)
Client
Node
106(4)
Client
Node
106(3)
Client
Node
106(2)
708
702

FIG. 7

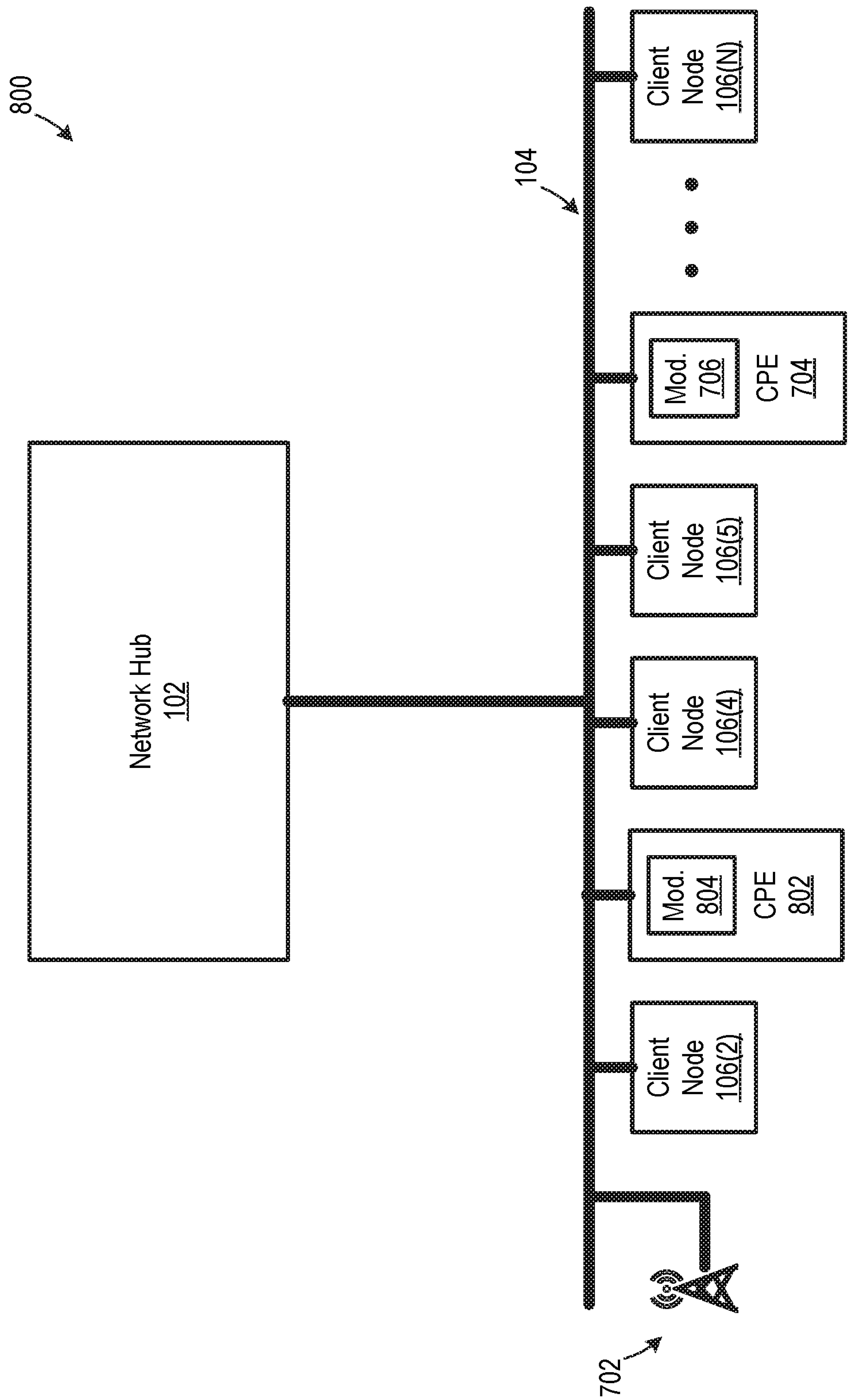
800
104
Network Hub 102
Client Node 106(N)
Mod. 706
CPE 704
Client Node 106(5)
Client Node 106(4)
Mod. 804
CPE 802
Client Node 106(2)
702

FIG. 8

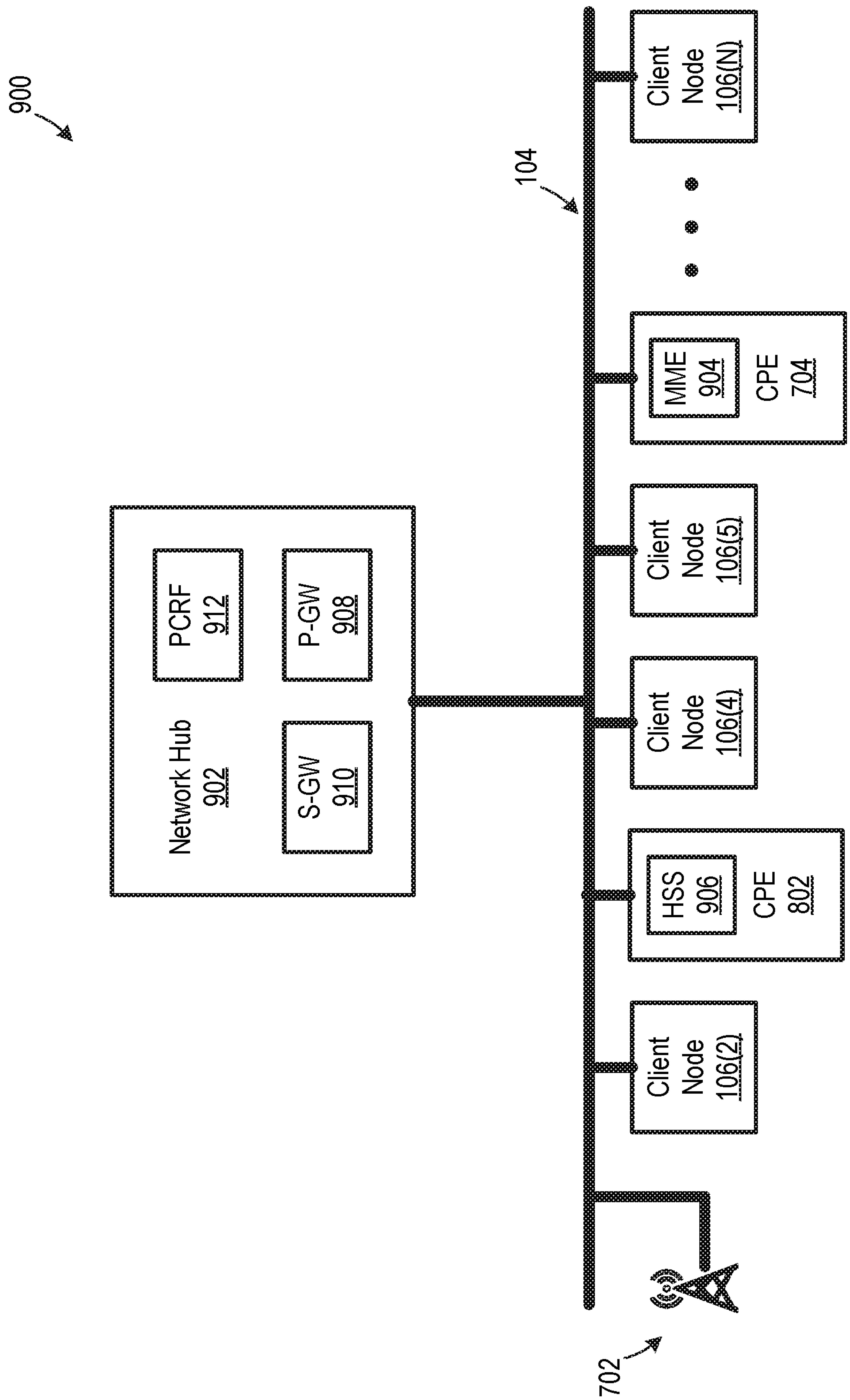
900
104
Client Node 106(N)
MME 904
CPE 704
Client Node 106(5)
Client Node 106(4)
HSS 906
CPE 802
Client Node 106(2)
Network Hub 902
PCRF 912
P-GW 908
S-GW 910
702

FIG. 9

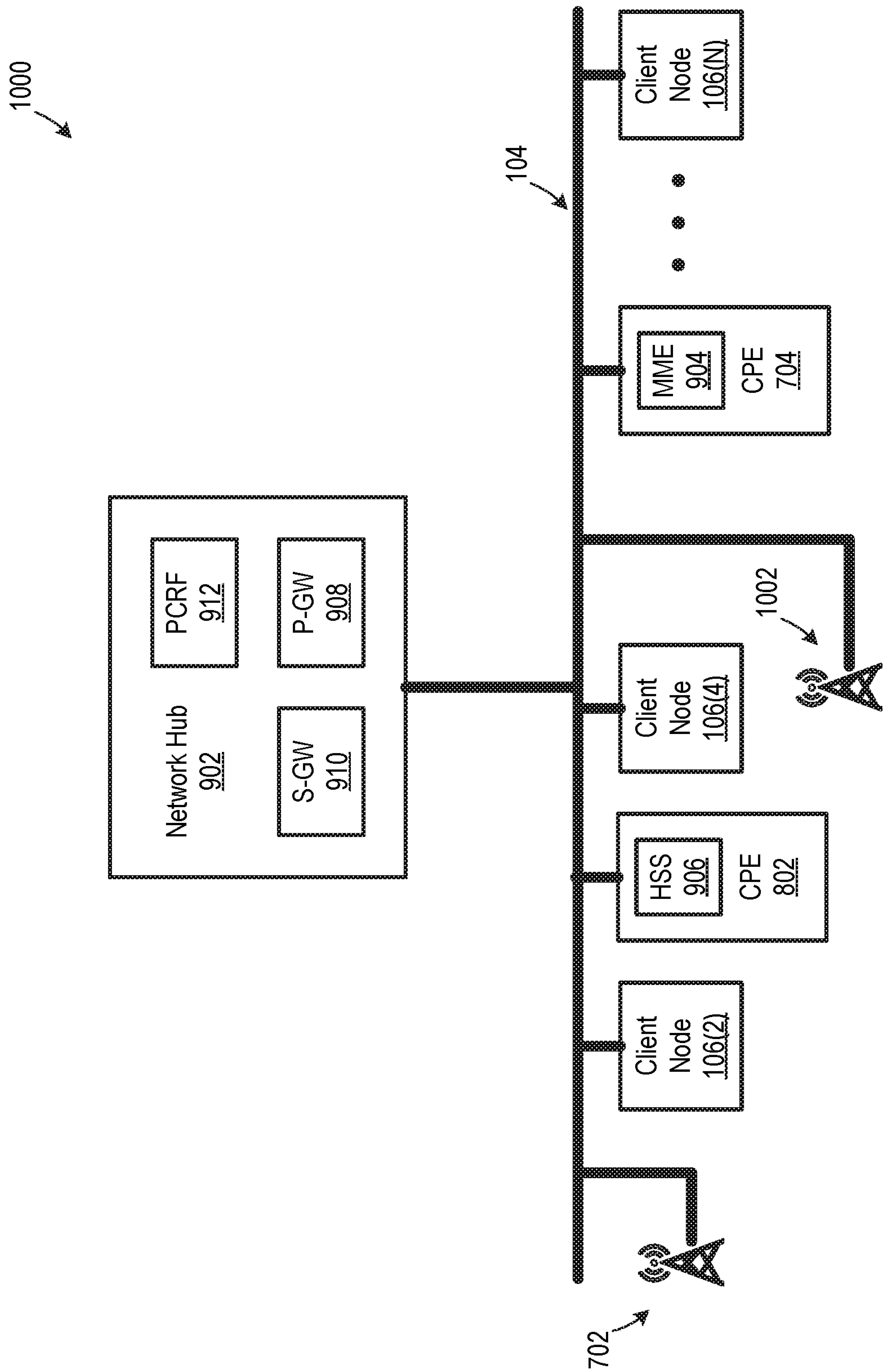
1000
104
Client Node 106(N)
MME 904
CPE 704
Network Hub 902
PCRF 912
P-GW 908
S-GW 910
1002
Client Node 106(4)
HSS 906
CPE 802
Client Node 106(2)
702

FIG. 10

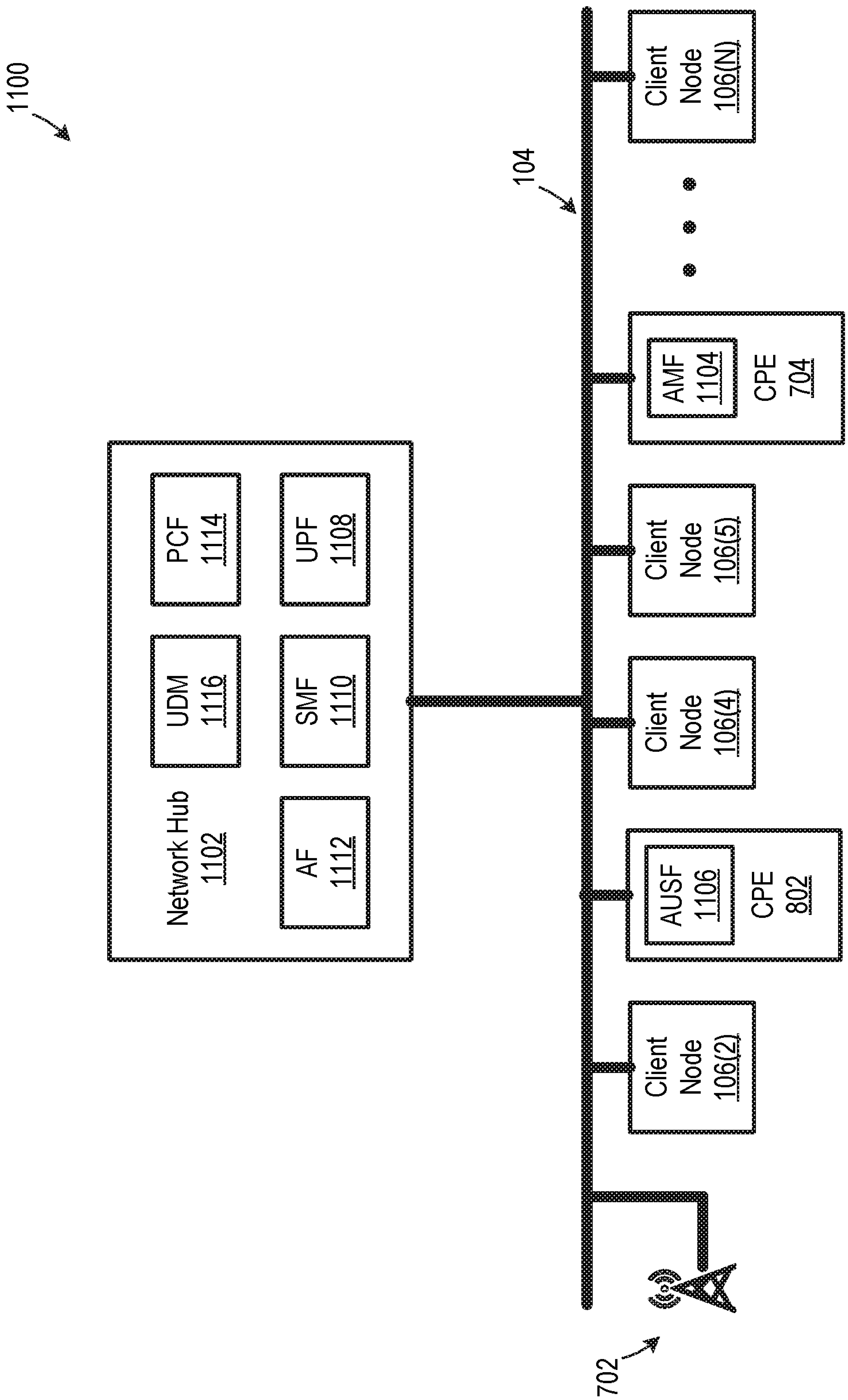
1100
104
Client Node 106(N)
AMF 1104
CPE 704
Client Node 106(5)
Client Node 106(4)
AUSF 1106
CPE 802
Client Node 106(2)
Network Hub 1102
PCF 1114
UPF 1108
UDM 1116
SMF 1110
AF 1112
702

FIG. 11

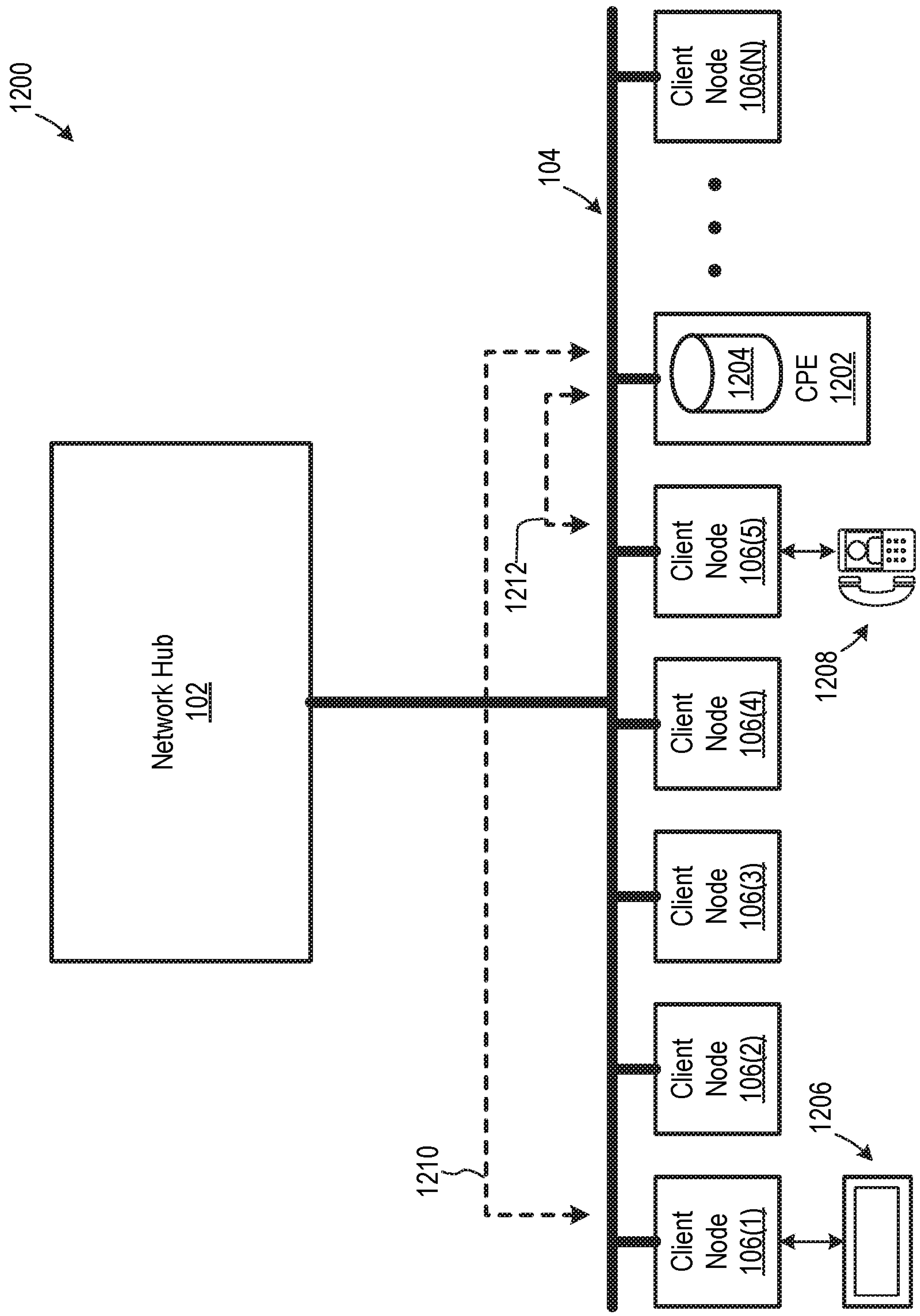
1200
Network Hub
102
104
Client Node
106(N)
1204
CPE
1202
Client Node
106(5)
1208
1212
Client Node
106(4)
Client Node
106(3)
Client Node
106(2)
1206
1210
Client Node
106(1)

FIG. 12

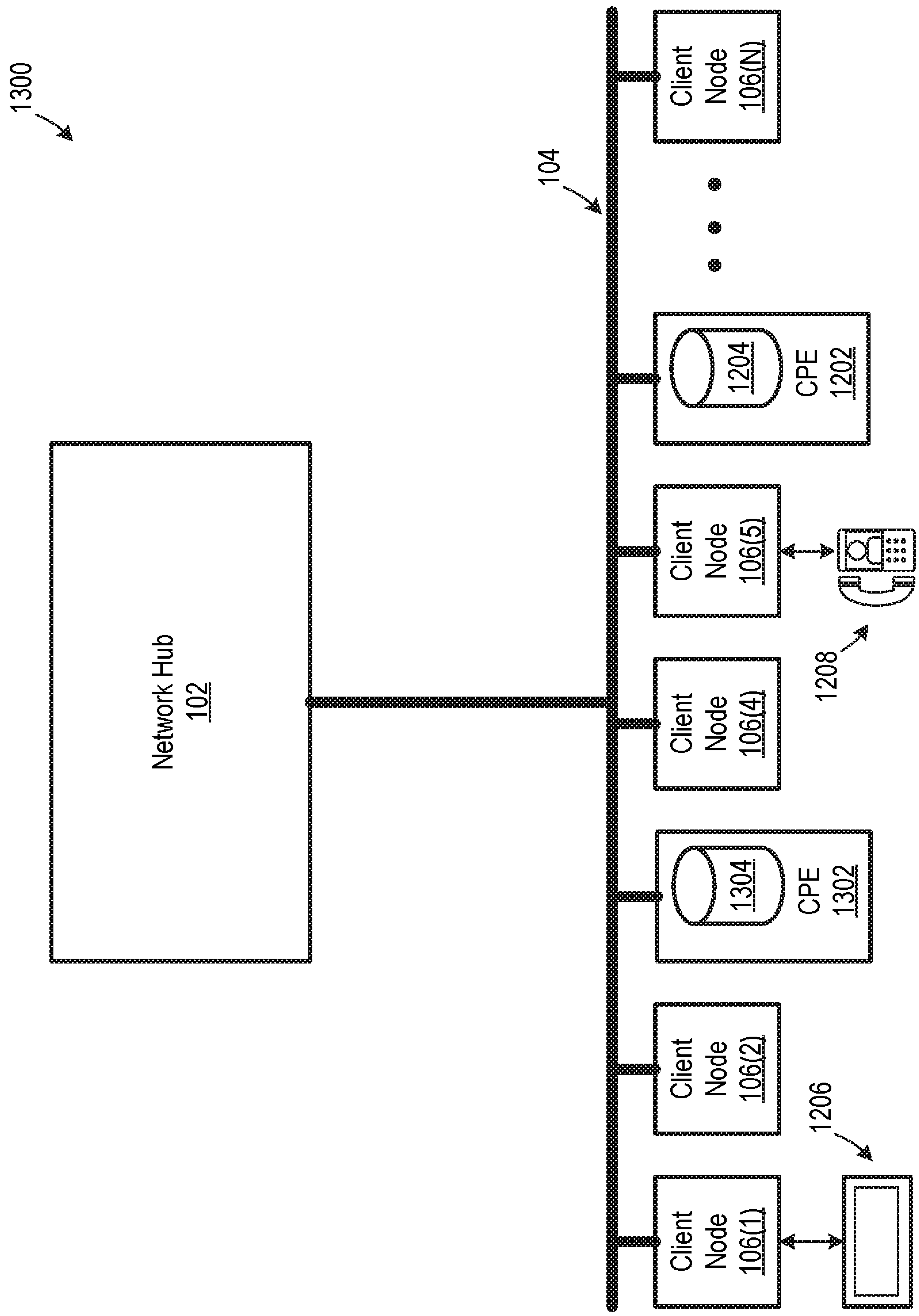
1300
104
Network Hub 102
Client Node 106(1)
Client Node 106(2)
CPE 1302
1304
Client Node 106(4)
Client Node 106(5)
CPE 1202
1204
Client Node 106(N)
1206
1208

FIG. 13

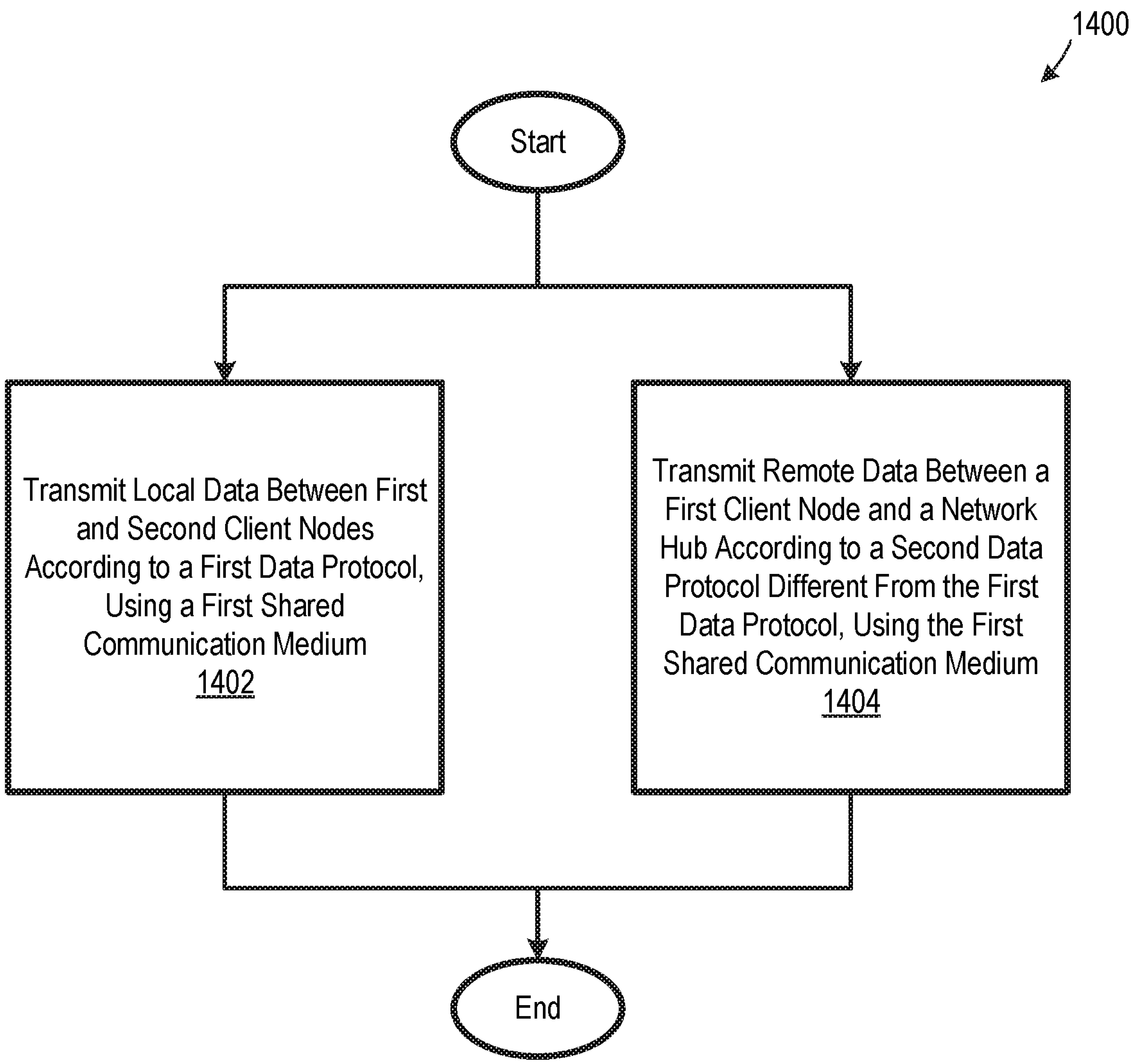
1400
Start
Transmit Local Data Between First and Second Client Nodes According to a First Data Protocol, Using a First Shared Communication Medium
1402
Transmit Remote Data Between a First Client Node and a Network Hub According to a Second Data Protocol Different From the First Data Protocol, Using the First Shared Communication Medium
1404
End

FIG. 14

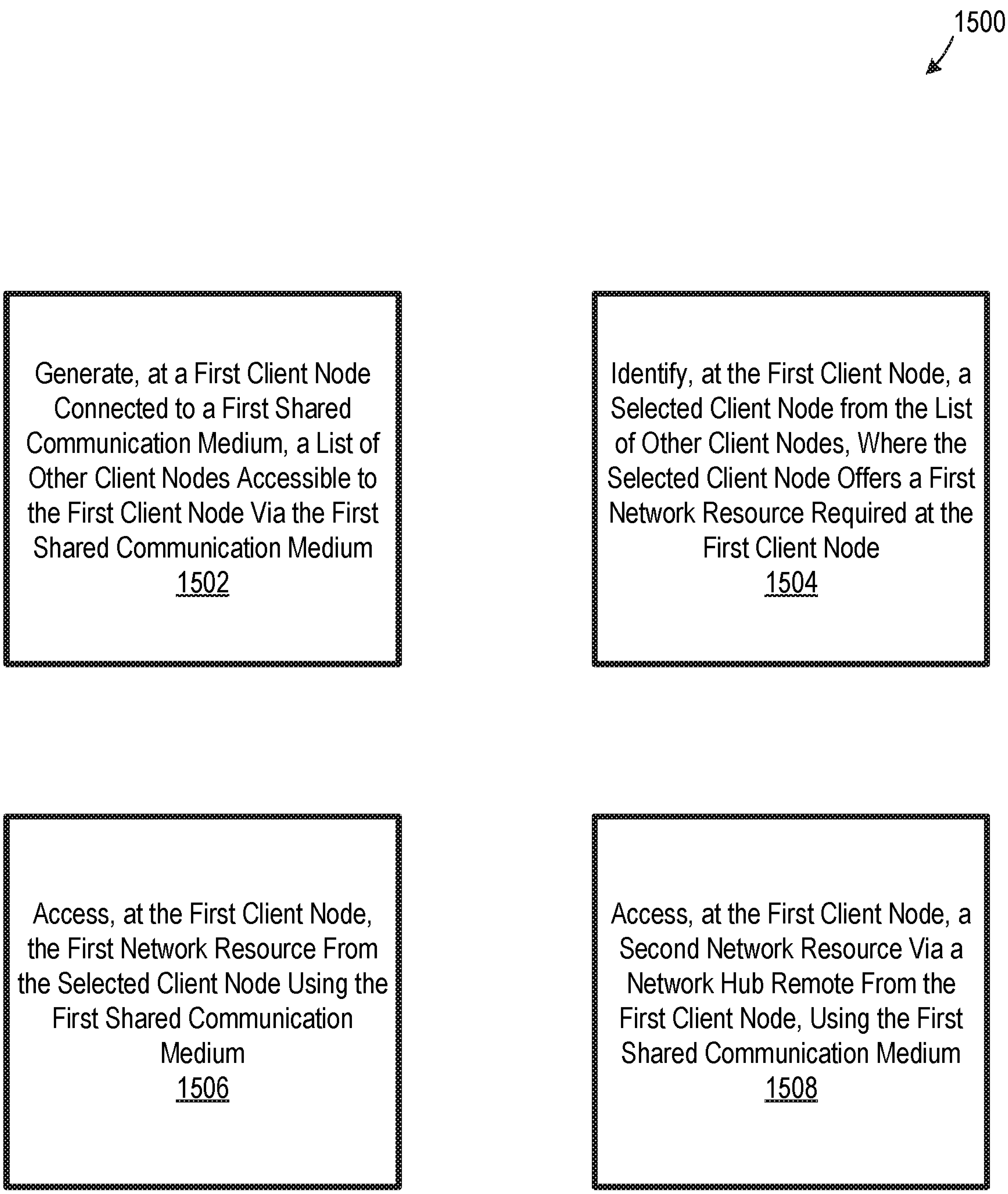
1500
Generate, at a First Client Node Connected to a First Shared Communication Medium, a List of Other Client Nodes Accessible to the First Client Node Via the First Shared Communication Medium
1502
Identify, at the First Client Node, a Selected Client Node from the List of Other Client Nodes, Where the Selected Client Node Offers a First Network Resource Required at the First Client Node
1504
Access, at the First Client Node, the First Network Resource From the Selected Client Node Using the First Shared Communication Medium
1506
Access, at the First Client Node, a Second Network Resource Via a Network Hub Remote From the First Client Node, Using the First Shared Communication Medium
1508

FIG. 15

COMMUNICATION NETWORKS INCLUDING MULTI-PURPOSE SHARED COMMUNICATION MEDIUMS, AND ASSOCIATED METHODS

RELATED APPLICATIONS

This application claims benefit of priority to U.S. Provisional Patent Application Ser. No. 62/672,527, filed on May 16, 2018, which is incorporated herein by reference.

BACKGROUND

Many communication networks use a shared communication medium to enable multiple client nodes to communicate with a network hub. For example, cable communication networks commonly use a shared coaxial electrical cable to enable multiple cable modems to communicate with a cable headend, and optical communication networks frequently use a shared optical cable to enable multiple optical network terminals (ONTs) to communicate with an optical line terminal (OLT). Multiple client nodes may share a common communication medium, for example, by using the shared communication medium at different respective times and/or by using different respective frequency bands on the shared communication medium. Use of a shared communication medium promotes cost-effectiveness by eliminating the need to provide a respective cable for each client node.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of a communication network including a multi-purpose shared communication medium, according to an embodiment.

FIG. **2** is a block diagram of a client node, according to an embodiment.

FIG. **3** is a schematic diagram of another communication network including a multi-purpose shared communication medium, according to an embodiment.

FIG. **4** is a graph illustrating one possible allocation of frequency bands in the communication networks of FIGS. **1** and **3**, according to an embodiment.

FIG. **5** is a schematic diagram of another communication network including a multi-purpose shared communication medium, according to an embodiment.

FIG. **6** is a graph illustrating one possible allocation of frequency bands in the communication network of FIG. **5**, according to an embodiment.

FIG. **7** is a schematic diagram of a communication network including a multi-purpose shared communication medium where a client node hosts a wireless communication network control module, according to an embodiment.

FIG. **8** is a schematic diagram of a communication network including a multi-purpose shared communication medium where two client nodes host respective wireless communication network control modules, according to an embodiment.

FIG. **9** is a schematic diagram of a communication network including a multi-purpose shared communication medium where two client nodes host respective elements of a long-term evolution packet core, according to an embodiment.

FIG. **10** is a schematic diagram of another communication network including a multi-purpose shared communication medium where two client nodes host respective elements of a long-term evolution packet core, according to an embodiment.

FIG. **11** is a schematic diagram of a communication network including a multi-purpose shared communication medium where two client nodes host respective elements of a fifth generation, new radio packet core, according to an embodiment.

FIG. **12** is a schematic diagram of a communication network including a multi-purpose shared communication medium where a client node hosts a content server, according to an embodiment.

FIG. **13** is a schematic diagram of a communication network including a multi-purpose shared communication medium where two client nodes host respective content servers, according to an embodiment.

FIG. **14** is a flow chart illustrating a method for transmitting data in a communication network including a shared communication medium, according to an embodiment.

FIG. **15** is a block diagram illustrating a method for transmitting data in a communication network including a shared communication medium, according to an embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Need for communication networks is anticipated to significantly grow in the foreseeable future. For example, communication networks subscribers are increasingly using communication networks to obtain streaming content, e.g. steaming video and streaming audio. As another example, the emerging fields of virtual reality (VR) and augmented reality (AR) typically require transmission of large amounts of data via a communication network. Furthermore, small wireless base stations, sometime referred to as "small cells," are being rapidly deployed to support new wireless communication technologies, such as fifth-generation (5G) new radio (NR) wireless communication networks. Each small cell requires a communication network to provide backhaul data transmission between the small cell and a wireless packet core.

One way to meet increased communication network demand is to deploy additional communication media. For example, additional optical and/or electrical cables may be deployed between two points to increase communication network capacity between these two points. Additionally, a given communication medium can sometimes be replaced with a higher-capacity communication medium. For an example, an electrical cable can potentially be replaced with an optical cable to increase communication network capacity. While these techniques can be effective in increasing communication network capacity, they are frequently expensive. Additionally, adding or replacing communication cables may be disruptive, such as by requiring trenching and associated damage to paved surfaces and/or landscaping, to install underground cables.

Disclosed herein are communication networks and associated methods which help increase communication network capacity without requiring addition of communication media or replacement of communication media. The new communication networks achieve increased communication network capacity by enabling a shared communication medium to serve multiple purposes, e.g. to transmit data between client nodes on the shared communication medium, as well as to transmit data between client nodes and a network hub. In conventional communication networks, in contrast, a shared communication medium is used only for data transmission between client nodes and a network hub.

Thus, the new communication networks use a shared communication medium more-efficiently than conventional communication networks.

FIG. **1** is a schematic diagram of a communication network **100**, which is one embodiment of the new communication networks which include a multi-purpose shared communication medium. Communication network **100** includes a network hub **102**, a shared communication medium **104**, and N client nodes **106**, where N is an integer greater than one. Although FIG. **1** depicts communication network **100** with N being greater than 6, N could be 6 or less without departing from the scope hereof. In this document, specific instances of an item may be referred to by use of a numeral in parentheses (e.g., client node **106**(**1**)) while numerals without parentheses refer to any such item (e.g., client nodes **106**). Each client node **106** and network hub **102** are communicatively coupled to shared communication medium **104**. In some alternate embodiments of communication network **100**, however, there are one or more intervening communication mediums between shared communication medium **104** and network hub **102**, such as discussed below with respect to FIG. **3**.

Network hub **102** is a central network element of communication network **100**. In some embodiments, network hub **102** includes one or more of a cable headend, a telecommunications central office, an OLT, a wireless communication network core, and a converged communication core (e.g. supporting both wireline and wireless communication). In embodiments where network hub **102** supports wireless communication, network hub **102** optionally supports one or more of the following wireless communication protocols: a long-term evolution (LTE) wireless communication protocol, 5G NR wireless communication protocol (e.g. licensed and/or unlicensed), a sixth generation (6G) wireless communication protocol, an unlicensed radio spectrum communication protocol (e.g. a Wi-Fi protocol), and extensions and/or variations thereof.

Shared communication medium **104** is used by each client node **106**, as well as by network hub **102**, to transmit information. In some embodiments, shared communication medium **104** is one or more of a coaxial electrical cable and an optical cable. One or more client nodes **106** are, for example, customer premises equipment (CPE), such as equipment located at a residence or a business. Examples of a customer premises equipment include, but are not limited to, a cable modem, a ONT, and/or a premises gateway. A premises gateway includes, for example, a communication device, such as a cable modem or an ONT, along with additional equipment, such as equipment providing networking functionality, data storage, and/or wireless communication (e.g. Wi-Fi or other unlicensed or licensed wireless communication). However, client nodes **106** are not limited to customer premises equipment. For example, in some embodiments, one or more client nodes **106** are a wireless base station, infrastructure equipment (e.g. utility or transportation equipment), network equipment (e.g. an amplifier or a repeater), or a connection to another communication network. Examples of possible wireless base stations include, but are not limited to, a LTE wireless base station, 5G NR wireless base station, a 6G wireless base station, an unlicensed radio spectrum wireless base station (e.g. a Wi-Fi or unlicensed NR), or extensions and/or variations thereof. Each client node **106** need not have the same configuration. For example, client node **106**(**1**) could be CPE, and client node **106**(**2**) could be a wireless base station.

Communication network **100** is configured to use shared communication medium **104** for at least two purposes. First, communication network **100** uses shared communication medium **104** to transmit local data between a least two client nodes **106** according to a first data protocol. FIG. **1** illustrates one example of local data transmission where local data **108** is transmitted between client node **106**(**1**) and client node **106**(**3**) using shared communication medium **104**. Second, communication network **100** uses shared communication medium **104** to transmit remote data between client nodes **106** and network hub **102** according to a second data protocol different from the first data protocol. FIG. **1** illustrates one example of remote data transmission where remote data **110** is transmitted between client node **106**(**1**) and network hub **102** using at least shared communication medium **104**. Local data is data that is transmitted between two client nodes **106** without being transmitted through network hub **102**, and remote data is data transmitted between a client node **106** and network hub **102**. Examples of the first data protocol include, but are not limited to, a Wi-Fi-based data protocol, an Internet (IP) data protocol, and a content centric networking (CCN) data protocol. Examples of the second data protocol include, but are not limited to, a data over cable service interface specification (DOCSIS) data protocol, a ethernet passive optical network (EPON) data protocol, a radio frequency over glass (RFOG) data protocol, and a gigabit passive optical network (GPON) data protocol. In some embodiments where there are one or more intervening communication mediums between shared communication medium **104** and network hub **102**, remote data may be transmitted according to one or more data protocols in addition to the second data protocol.

As discussed above, conventional communication networks use a shared communication medium for one purpose, i.e. to transmit data between client nodes and a network hub. Communication network **100**, in contrast, uses shared communication medium **104** for at least two purposes, e.g. for transmission of both local and remote data. Therefore, communication network **100** can potentially achieve higher capacity than conventional communication networks with similar shared communication media. Additionally, the relatively short path between client nodes **106** via shared communication medium **104** helps minimize latency of local data transmission. For example, in some embodiments, latency of local data between client nodes **106** is less than ten milliseconds (ms). In contrast, distance between client nodes **106** and network hub **102** may be relatively long, potentially causing significant latency of remote data between client devices **106** and network hub **102**. Additionally, Applicant has determined that communication network **100**'s ability to transfer local data between client nodes **106** in a peer-to-peer manner can be exploited to increase communication network performance and/or scalability. For example, network resources that are conventionally available only via network hub **102** can be deployed at one or client nodes **106**, thereby reducing the need for client nodes **106** to communicate with network hub **102**. Additionally, deploying network resources at client nodes **106** promotes high performance due to the minimal latency associated with local data transmission. Some examples of deploying wireless communication network resources and content delivery network resources at client nodes **106** are discussed below with respect to FIGS. **7**-**13**.

FIG. **2** is a block diagram of a client node **200**, which is one possible embodiment of a client node **106** instance. It should be appreciated, however, that client nodes **106** are not limited to the embodiment of FIG. **2**. To the contrary, client nodes **106** can have essentially any configuration as long as they are able to communicate with other client nodes **106**, as well as with network hub **102**, using shared communication medium **104**.

Client node **200** includes a processor **202**, a memory **204**, a first communication module **206**, and a second communication module **208**. Client node **200** may include additional elements without departing from the scope hereof. Processor **202** is configured to execute instructions **210** stored in memory **204** to control at least some aspects of client node **200**. Instructions include **210**, for example, firmware and/or software. First communication module **206** support communication with other client nodes **106/200** using the first data protocol, e.g. Wi-Fi-based protocol, an IP data protocol, or a CCN data protocol. Second communication module **208** supports communication with network hub **102** using the second data protocol, e.g. a DOCSIS data protocol, a EPON data protocol, a RFOG data protocol, or a GPON data protocol.

Although first communication module **206** and second communication module **208** are illustrated as being separate logical elements, they may share at least some common components. For example, in some embodiments, first communication module **206** and second communication module **208** share one or more physical layer elements, e.g. transceivers which electrically and/or optically interface client node **200** with shared communication medium **104**. Additionally, while first communication module **206** and second communication module **208** are illustrated as being separate from processor **202** and memory **204**, in some embodiments, first communication module **206** and second communication module **208** are at least partially implemented by processor **202** executing instructions **210**.

In particular embodiments, local data may be attenuated on shared communication medium **104** so that a given client node **106/200** will not necessarily be able to directly communicate with all client node **106/200** instances using shared communication medium **104**. For example, in one embodiment of communication system **100** (FIG. **1**), client node **106(3)** may able to communication with relatively-close client nodes **106(1)**, **106(2)**, **106(4)**, and **106(5)**, but client node **106(3)** may be unable to communicate with more-distant client nodes **106(6)**-**106**(N) due to signal attenuation on shared communication medium **104**. Therefore, in certain embodiments, each client node **106** is configured to generate a list of other client nodes accessible to the client node via shared communication medium **104**. For example, returning to FIG. **2**, in some embodiments, processor **202** is configured to execute instructions **210** to generate a routing table **212** stored in memory **204**. Routing table **212** includes a list of other client nodes **106/200** accessible to client node **200** via shared communication medium **104**, and routing table **212** may include a list of available network resources hosted by each client node on the list.

For example, assume that client node **200** is client node **106(3)** of FIG. **1** and that client node **200** can communicate with only relatively-close client nodes **106(1)**, **106(2)**, **106(4)**, and **106(5)**. In this example, client node **200** accordingly generates routing table **212** listing client nodes **106(1)**, **106(2)**, **106(4)**, and **106(5)**, which are the client nodes accessible to client node **200**. Additionally, assume that (a) client node **106(1)** hosts network resource X, (b) client node **106(2)** hosts network resources Y and Z, (c) client node **106(4)** does not host any network resources, and that client node **106(5)** hosts network resource A. Client node **200** accordingly generates routing table **212** to associate these network resources with their respective client nodes **106**. In some embodiments, network resources X, Y, Z, and A include one or more of a wireless communication network control module and a content server.

In certain embodiments, client node **200** is further configured to route data as either local data or remote data depending on availability of an appropriate network resource at a client node **106/200**. For example, assume again that client node **200** is client node **106(3)** of FIG. **1**, and assume that network resource Z is required at client node **200**. In this example, client node **200** determines from routing table **212** that network resource Z is available at client node **106(2)**. Client node **200** accordingly accesses network resource Z from client node **106(2)** using shared communication medium **104**, i.e. client node **200** routes local data between client node **200** and network resource Z. Now assume that network resource B (not shown) is required at client node **200**. Network resource B is not hosted by any of client nodes **106**, and network resource B must therefore be accessed via network hub **102**. Network resource B is, for example, a network resource available only via the Internet. Client node **200** determines from routing table **212** that network resource B is not available at client node **200** via another client node **106**. Client node **200** therefore accesses network resource B via network hub **102**, i.e. client node **200** routes remote data between client node **200** and network hub **102**.

In particular embodiments, processor **202** further executes instructions **210** to create a network resource **214**, which is hosted by client node **200** in memory **204**. Network resource **214** is, for example, a wireless communication network resource or a content delivery network resource, in some embodiments. Network resource **214** may be directly accessed by other client nodes **200/106** via shared communication medium **104**, in certain embodiments.

In some embodiments, client node **200** is part of CPE including, but are not limited to, a cable modem, a ONT, or a premises gateway. In some other embodiments, client node **200** is a wireless base station, infrastructure equipment (e.g. utility or transportation equipment), network equipment (e.g. an amplifier or a repeater), or a connection to another communication network.

The elements of client node **200** could be combined and/or divided without departing from the scope hereof. For example, memory **204** could include multiple elements, such as solid-state memory and a hard drive. As another example, processor **202** could including multiple co-processors. The elements of client node **200** may be commonly packaged, such as if client node **200** is a premises gateway. Alternately, two or more elements of client node **200** could be separately packaged or even disposed in different respective physical locations. For example, the elements of client node **200** could be distributed among multiple data centers.

Referring again to FIG. **1**, in some embodiments there are one or more intervening communication mediums between shared communication medium **104** and network hub **102**. That is, in these embodiments, shared communication medium **104** is not directly connected to network hub **102**. For example, FIG. **3** is a schematic diagram of a communication network **300**, which is another embodiment of the new communication networks including a multi-purpose shared communication medium. Communication network **300** is similar to communication network **100** of FIG. **1**, but communication network **300** further includes a translation device **301** and a backhaul communication medium **303**. Backhaul communication medium **303** communicatively couples translation device **301** and network hub **102**, and translation device **301** communicatively couples shared communication medium **104** and backhaul communication medium **303**. Backhaul communication medium **303** is physically different from, and/or operates in a different manner than, shared communication medium **104**. For example, in one embodiment, shared communication medium **104** includes a coaxial electrical cable, backhaul communication medium **303** includes an optical cable, and translation device **301** includes a fiber node. As another example, is another embodiment, shared communication medium **104** and backhaul communication medium **303** are each an optical cable, but backhaul communication medium **303** has a different physical configuration, or operates differently from, shared communication medium **104**.

Remote data will travel through each of shared communication medium **104**, translation device **301**, and backhaul communication medium **303**, in communication network **300**. For example, FIG. **3** illustrates remote data **310** being transmitted between client node **106(1)** and network hub **102** via shared communication medium **104**, translation device **301**, and backhaul communication medium **303**.

In some embodiments, local data and remote data are transmitted on different respective frequency bands over shared communication medium **104**, to enable simultaneous transmission of local data and remote data over shared communication medium **104**. For example, FIG. **4** is a graph illustrating one possible allocation of frequency bands in communication networks **100** and **300**. In the FIG. **4** embodiment, remote uplink data is transmitted via a lower-frequency band **402**, remote downlink data is transmitted via a higher-frequency band **404**, and local data is transmitted via a frequency band **406** between the two remote data frequency bands. Consequently, local data and remote data can be simultaneously transmitted over shared communication medium **104**.

In some embodiments of communication networks **100** and **300**, two or more segments of shared communication medium **104** are coupled via one or more signal processing devices, such as amplifiers or repeaters. In some embodiments, the signal processing devices only transmit signals within certain frequencies, such that local data signals will be blocked unless they are in a frequency range transmitted by the signal processing devices. For example, FIG. **5** is a schematic diagram of a communication network **500**, which is another embodiment of the new communication networks including a multi-purpose shared communication medium. Communication network **500** is similar to communication network **300** of FIG. **3**, but communication network **500** further includes an amplifier **502** communicatively coupling segments **504** and **506** of shared communication medium **104**.

FIG. **6** is a graph illustrating one possible allocation of frequency bands in communication network **500**. Amplifier **502** is configured to transmit uplink and downlink signals in different frequency bands **602** and **604**, respectively. Uplink signals travel through amplifier **502** in a direction **508**, and downlink signals travel through amplifier **502** in a direction **510**, as illustrated in FIG. **5**. Accordingly, remote uplink data is transmitted via a lower-frequency band **606** within amplifier uplink frequency band **602**, and remote downlink data is transmitted via a higher-frequency band **608** within downlink frequency band **604**, as illustrated in FIG. **6**. Local data is additionally split into two different frequency bands to enable bi-directional transmission of local data signals through amplifier **502**. Specifically, local uplink data is transmitted via a frequency band **610** within amplifier uplink frequency band **602**, and local downlink data is transmitted via a frequency band **612** within downlink frequency band **604**.

The ability of communication networks **100**, **300**, and **500** to transmit local data via shared communication medium **104** may enable significant improvements in wireless communication network performance and wireless communication network scalability. In particular, significant data is transmitted through a network hub in the form of a packet core, in a conventional communication network supporting wireless communication. For example, in a conventional LTE wireless communication system, user plane data is transmitted between a wireless base station and a Serving Gateway (S-GW) of a packet core, and control plane data is transmitted between the wireless base station and a Mobility Management Entity (MME) of the packet core. As another example, in a conventional 5G wireless communication network, user plane data is transmitted between a wireless base station and a User Plane Function (UPF) of a packet core, and control plane data is transmitted between the wireless base station and an Access and Management Mobility Function (AMF) of the packet core. Additionally, there may be significant data transmission between wireless base stations, which must flow through a network hub in conventional communication networks. For example, wireless base stations in a LTE wireless communication system may communicate with each other according to an X2 interface, such as to coordinate user equipment (UE) handoff and/or to prevent interference between neighboring wireless base stations.

Additionally, the emerging deployment of multiple small cells is anticipated to place even greater loads on communication networks. In particular, not only must control plane and user plane data be transmitted between each small cell and a packet core, densification of wireless base stations from small cell deployment is anticipated to markedly increase handoff of UE among wireless base stations, which will itself further increase control plane data traffic, because significant control plane data must between transmitted to enable UE handoffs. Indeed, Applicant has estimated that small cells may generate ten to twenty times the amount of control plane data than macro cells covering the same geographic area. Furthermore, anticipated large increase in UE, such as from growth in Internet of Things (IoT) devices, is expected to further increase amount of wireless communication data flowing through communication networks. Accordingly, conventional communication networks may have difficulty in handling communication requirements of future applications due to the large amount of data that must flow through a network hub. Additionally, the requirement that all data flow through a network hub in conventional communication networks may cause difficulty in scaling wireless communication networks, such as to support additional wireless base stations and/or additional UE.

Applicant has determined, however, that these problems can potentially be at least partially overcome by hosting wireless communication network resources in client nodes **106**, instead of in network hub **102**. The ability of communication networks **100**, **300**, and **500** to transmit local data advantageously enables direct communication between wireless base stations and wireless network resources using shared communication medium **104**, thereby reducing the need for wireless base stations to communicate with network hub **102**. Such use of shared communication medium **104** for data transmission between wireless communication resources promotes by high performance by minimizing latency in the data transmission, as data transmission via shared communication medium **104** is typically low-latency, as discussed above. Furthermore, transmission of wireless communication data solely via shared communication medium **104** reduces load on communication media connected to network hub **102**, thereby promoting overall communication network performance. Furthermore, the ability to host wireless network resources at client nodes **106** enables the wireless network resources to be distributed, thereby promoting wireless communication network scalability.

For example, FIG. **7** is a schematic diagram of a communication network **700**, which is another embodiment of the new communication networks including a multi-purpose shared communication medium. Communication network **700** is similar to communication network **100** of FIG. **1** but with (a) client node **106(1)** embodied by a wireless base station **702** and (b) client node **106(6)** embodied by CPE **704**. In some embodiments, wireless base station **702** is a LTE wireless base station, 5G NR wireless base station, a 6G wireless base station, an unlicensed radio spectrum wireless base station (e.g. a Wi-Fi or unlicensed NR), or extensions and/or variations thereof. Wireless base station **702** could also be part of a distributed wireless access point, such as a particular antenna/transceiver of the distributed wireless access point. CPE **704** hosts a wireless communication network control module **706**. In some embodiments, CPE **704** is an embodiment of client node **200** of FIG. **2** where wireless communication network control module **706** is an embodiment of network resource **214**.

Wireless communication network control module **706** supports wireless base stations, e.g. wireless base station **702**, communicatively coupled to shared communication medium **104**. In some embodiments, wireless communication network control module **706** implements one or more elements of a wireless communication network packet core, e.g. a LTE, 5G, or 6G packet core, which may advantageously reduce, or even eliminate, the need for wireless base station **702** to communicate with network hub **102**. Instead, wireless base station **702** may directly communicate with wireless communication network control module **706** via local data **708** using shared communication medium **104**.

In some embodiments, communication network **700** is configured to instantiate and terminate wireless communication network control module **706** in CPE **704** on demand, such as due to a change in operating conditions in communication network **700**. For example, communication network **700** may instantiate wireless communication network control module **706** in response to an increase in load on wireless base station **702**, to prevent excessive data flow between wireless base station **702** and network hub **102** resulting from the increased load on wireless base station **702**. As another example, communication network **700** may terminate wireless communication network control module **706** in CPE **704** in response to a decrease in load on wireless base station **702**. Accordingly, in particular embodiments, communication network **700** is configured to instantiate and terminate wireless communication network control modules to optimize operation of communication network **700**. In particular embodiments, network hub **102** controls instantiating and termination of network resources in client nodes **106/200/702/704**, while in some other embodiments, an external controller (not shown) controls instantiation and termination of network resources in client nodes **106/200/702/704**.

The communication systems disclosed herein are not limited to hosting network resource in a single client node. For example, FIG. **8** is a schematic diagram of a communication network **800**, which is another embodiment of the new communication networks including a multi-purpose shared communication medium. Communication network **800** is similar to communication network **700** of FIG. **7** but with client node **106(3)** embodied by CPE **802**. CPE **802** hosts a wireless communication network control module **804**. In some embodiments, CPE **802** is an embodiment of client node **200** of FIG. **2** where wireless communication network control module **804** is an embodiment of network resource **214**. In certain embodiments, wireless communication network control module **706** and wireless communication network control module **804** are different respective elements of a wireless communication network packet core. Communication network **800** could include additional network functions hosted by client nodes **106/200/702/704/802** without departing from the scope hereof. Additionally, a given client node **106/200/702/704/802** could host multiple network functions.

In some embodiments, each of wireless communication network control modules **706** and **804** is one or more of a LTE MME, a LTE S-GW, a Home Subscriber Server HSS, a LTE PDN Gateway (P-GW), a LTE Policy Control and Charging Rules Function (PCRF), a 5G UPF, a 5G AMF, a 5G Authentication Server Function (AUSF), a 5G Session Management Function (SMF), a 5G Application Function (AF), a 5G Unified Data Function (UDM), and a 5G Policy control function (PCF). However, wireless communication network control modules **706** and **804** are not limited to these example network resources.

Discussed below with respect to FIGS. **9** and **10** are examples of communication network **800** in LTE applications, and discussed below with respect to FIG. **11** is an example of communication network **800** in a 5G application. It should be appreciated, however, that communication network **800** is not limited to these example embodiments.

FIG. **9** is a schematic diagram of a communication network **900**, which is an embodiment of communication network **800** where CPE **704** and CPE **802** host a MME **904** and a HSS **906**, respectively. Additionally, network hub **102** is embodied as network hub **902** in FIG. **9**, where network hub **902** includes a P-GW **908**, a S-GW **910**, and a PCRF **912**. Hosting of MME **904** and HSS **906** by CPE **704** and **802**, respectively, advantageously enables control plane data between wireless base station **702**, MME **904**, and HSS **906** to be routed as local data on shared communication medium **104**. Such transmission of control plane data as local data eliminates latency associated with the control plane data traveling to network hub **902**, which may be distant from wireless base station **102**. Additionally, transmission of control plane data as local data helps reduce load on communication media connected to network hub **902**. User plane data, however, flows between wireless base station **702** and S-GW **910** of network hub **902**.

Communication network **900** could be modified so that additional, fewer, or different LTE packet core elements are hosted by client nodes. For example, in an alternate embodiment, HSS **906** is incorporated in network hub **902** instead of being hosted by CPE **802**. As another example, in another alternate embodiment, S-GW **910** is hosted by CPE **802** in addition to, or in place of, HSS **906**. As yet another example, in another alternate embodiment, S-GW **910** is hosted by client node **106(4)**, such that each of MME **904**, HSS **906**, and S-GW **910** are hosted by a respective client node on shared communication medium **104**.

FIG. **10** is a schematic diagram of a communication network **1000**, which is another embodiment of the new communication networks including a multi-purpose shared communication medium. Communication network **1000** is similar to communication network **800** of FIG. **8** but with client node **106(5)** embodied by a wireless base station **1002**.

Shared communication medium **104** enables direct communication between wireless base stations **702** and **1002** by transfer of local data, e.g. using a LTE X2 interface, such as for coordinating UE handoff, for preventing interference between wireless base stations **702** and **1002**, and/or for beam forming by wireless base stations **702** and **1002**. If either of wireless base stations **702** and **1002** needs to communicate with a wireless base station (not shown) that is not a client node of shared communication medium **104**, such communication would travel through network hub **902**, either via a LTE S1 or a LTE X2 interface. In some embodiments, wireless base stations **702** and **1002** are respective antennas/transceivers of a distributed wireless access point.

FIG. **11** is a schematic diagram of a communication network **1100**, which is an embodiment of communication network **800** where CPE **704** and **802** host an AMF **1104** and a AUSF **1106**, respectively. Additionally, network hub **102** is embodied as network hub **1102** in FIG. **11**, where network hub **1102** includes a UPF **1108**, a SMF **1110**, an AF **1112**, a PCF **1114**, and a UDM **1116**. Hosting of AMF **1104** and AUSF **1106** by CPE **704** and **802**, respectively, advantageously enables control plane data between wireless base station **702** and AMF **1104** and AUSF **1106** to be routed as local data on shared communication medium **104**, thereby eliminating latency associated with this control plane data traveling to network hub **1102** and helping reduce load on communication media connected to network hub **1102**. User plane data, however flows between wireless base station **702** and UPF **1108** of network hub **1102**.

Communication network **1100** could be modified so that additional, fewer, or different 5G packet core elements hosted by client nodes. For example, in an alternate embodiment, AUSF **1106** is incorporated in network hub **1102** instead of being hosted by CPE **802**. As another example, in another alternate embodiment, UPF **1108** is hosted by CPE **802** in addition to, or in place of, AUSF **1106**. As yet another example, in another alternate embodiment, UPF **1108** is hosted by client node **106**(**4**), such that each of AMF **1104**, AUSF **1106**, and UPF **1108** are hosted by a respective client node on shared communication medium **104**.

The ability of communication networks **100**, **300**, and **500** to transmit local data via shared communication medium **104** may also enable significant improvements in content distribution. In particular, content is conventionally delivered to client nodes via a network hub from one or more content servers upstream from the network hub. Such content delivery method places significant load on the network hub and communication media connected to the network hub. Furthermore, multiple data streams of the same content may be transmitted to different client nodes, resulting in inefficient use of communication media, when delivering content using conventional techniques.

Applicant has determined, however, that these problems can potentially be at least partially overcome by hosting content servers in client nodes **106**, instead of upstream from network hub **102**. The ability of communication networks **100**, **300**, and **500** to transmit local data advantageously enables direct communication between content servers and content consumers at client nodes **106**, thereby reducing the need for client nodes **106** to receive content via network hub **102**. Such use of shared communication medium **104** to transmit content locally stored in content servers hosted by client nodes **106** promotes by high performance by minimizing latency in the data transmission between content servers and content consumers, as data transmission via shared communication medium **104** is typically low-latency, as discussed above. Furthermore, transmission of content data solely via shared communication medium **104** reduces load on communication media connected to network hub **102**, thereby promoting overall communication network performance. Furthermore, the ability to host content servers at client nodes **106** enables content storage to be distributed, thereby promoting scalability in content storage.

For example, FIG. **12** is a schematic diagram of a communication network **1200**, which is another embodiment of the new communication networks including a multi-purpose shared communication medium. Communication network **1200** is similar to communication network **100** of FIG. **1** but with client node **106**(**6**) embodied by CPE **1202** hosting a content server **1204**. Additionally, communication network **1200** includes (a) a video display **1206** communicatively coupled to client node **106**(**1**) and (b) a video telephone **1208** communicatively coupled to client node **106**(**5**). Some possible examples of content stored by content server **1204** include, but are not limited to, video data, audio data, virtual reality data, and augmented reality data. In some embodiments, content server **1204** is an embodiment of client node **200** of FIG. **2** where content server **1204** is an embodiment of network resource **214**.

Content server **1204** provides content to client nodes **106** via shared communication medium **104**. Consequently, client nodes **106** can access content data stored in content server **1204** as local data, and client nodes **106** can therefore access the content stored in content server **1204** without accessing network hub **102**. For example, FIG. **12** illustrates client node **106**(**1**) accessing content from content server **1204** as local data **1210** for display on video display **1206**, and FIG. **12** further illustrates client node **106**(**5**) accessing content from content server **1204** as local data **1212** for display on video telephone **1208**. Transmitting content data as local data promotes high performance because shared communication medium **104** typically has low-latency, as discussed above. Additionally, hosting of content server in CPE **1202** eliminates the need for associated content data to flow to network hub **1202**, thereby helping conserve bandwidth of communication media connected to network hub **102**.

In some embodiments, communication network **1200** is configured to instantiate and terminate content server **1204** in CPE **1202** on demand, such as due to a change in operating conditions in communication network **1200**. For example, communication network **1200** may instantiate content server **1204** in response to a request for content from a client node **106**. As another example, communication network **1200** may terminate content server **1204** in CPE **1202** in response to a client node **106** no longer requesting content. Accordingly, in particular embodiments, communication network **1200** is configured to instantiate and terminate content servers to optimize operation of communication network **1200**. In particular embodiments, network hub **102** controls instantiating and termination of client servers in client nodes **106**/**200**/**1202**, while in some other embodiments, an external controller (not shown) controls instantiation and termination of network resources in client nodes **106**/**200**/**1202**.

The communication systems disclosed herein are not limited to hosting a content server in a single client node. For example, FIG. **13** is a schematic diagram of a communication network **1300**, which is another embodiment of the new communication networks including a multi-purpose shared communication medium. Communication network **1300** is similar to communication network **1200** of FIG. **12** but with client node **106**(**3**) embodied by CPE **1302**. CPE **1302** hosts a content server **1304**. In some embodiments, content server **1304** is an embodiment of client node **200** of FIG. **2** where content server **1304** is an embodiment of network resource **214**. Communication network **1300** could include additional network resources hosted by client nodes **106**/**200**/**1202**/**1302** without departing from the scope hereof. Additionally, a given client node **106**/**200**/**1202**/**1302** could host multiple network resources.

Client nodes **106** could host additional or alternative network resources. For examples, in some embodiments, client nodes **106** host network resources such as edge computing services, virtual reality services, and/or augmented reality services.

FIG. **14** is a flow chart illustrating a method **1400** for transmitting data in a communication network including a shared communication medium. In a block **1402**, local data is transmitted between a first client node and a second client node according to a first data protocol, using a first shared communication medium. In one example of block **1402**, local data **108** is transmitted between client nodes **106**(**1**) and **106**(**3**) according to a first data protocol, using shared communication medium **104** [FIG. **1**]. In a block **1404**, remote data is transmitted between the first client node and a network hub according to a second data protocol different from the first data protocol, using at least the first shared communication medium. In one example of block **1404**, remote data **110** is transmitted between client node **106**(**1**) and network hub **102** according to a second data protocol, using shared communication medium **104**. Although FIG. **14** illustrates blocks **1402** and **1404** being executed in parallel, blocks **1402** and **1404** could be executed in series without departing from the scope hereof.

FIG. **15** is a block diagram illustrating a method **1500** for transmitting data in a communication network including a shared communication medium. In a block **1502**, a list of other client nodes accessible to a first client node via a first shared communication medium is generated at the first client node, where the first client node is connected to the first shared communication medium. In one example of block **1502**, client node **200** generates routing table **212** [FIG. **2**]. In a block **1504**, a selected client node is identified at the first client node from the list of other client nodes, where the selected client node offers a first network resource required at the first client node. In one example of block **1504**, client node **106**(**5**) is identified, at client node **200**, as offering network resource A. In a block **1506**, the first network resource is accessed at the first client node from the selected client node using the first shared communication medium. In one example of block **1506**, network resource A is accessed at client node **200** from client node **106**(**5**) using shared communication medium **104**. In a block **1508**, a second network resource is accessed at the first client node via a network hub remote from the first client node, using the shared communication medium. In one example of block **1508**, client node **200** accesses a second network resource via network hub **102**, using shared communication medium **104**. The blocks of method **1500** could be executed in parallel and/or series.

Combinations of Features

Features described above may be combined in various ways without departing from the scope hereof. The following examples illustrate some possible combinations:

(A1) A method for transmitting data in a communication network including a shared communication medium may include (1) transmitting local data between a first client node and a second client node according to a first data protocol, using a first shared communication medium and (2) transmitting remote data between the first client node and a network hub according to a second data protocol different from the first data protocol, using at least the first shared communication medium.

(A2) The method denoted as (A1) may further include simultaneously (1) transmitting the local data between the first client node and the second client node via one or more first frequency bands using the first shared communication medium and (2) transmitting the remote data between the first client node and the network hub via one or more second frequency bands using at least the first shared communication medium, the one or more first frequency bands being different from the one or more second frequency bands.

(A3) Any one of the methods denoted as (A1) and (A2) may further include (1) determining that a network resource required at the first client node is available at the second client node and (2) in response to determining that the network resource is available at the second client node, accessing the network resource at the first client node from the second client node using the first shared communication medium.

(A4) Any one of the methods denoted as (A1) and (A2) may further include (1) determining that a network resource required at the first client node is not available to the first client node via another client node communicatively coupled to the first communication medium and (2) in response to determining that the network resource is not available to the first client node via another client node communicatively coupled to the first communication medium, accessing the network resource via the network hub.

(A5) In any one of the methods denoted as (A1) through (A4), the local data may include wireless communication network control data transmitted between a wireless base station at the first client node and a wireless communication network control module at the second client node.

(A6) The method denoted as (A5) may further include instantiating the wireless communication network control module in customer premises equipment at the second client node.

(A7) Any one of the methods denoted as (A5) and (A6) may further include instantiating the wireless communication network control module in the customer premises equipment in response to a change in operating conditions in the wireless communication network.

(A8) In any one of the methods denoted as (A5) through (A7), the wireless communication network control module may include at least one of a Mobility Management Entity (MME), a Serving Gateway (S-GW), a Home Subscriber Server (HSS), a PDN Gateway (P-GW), a Policy Control and Charging Rules Function (PCRF), a User Plane Function (UPF), an Access Management Mobility Function (AMF), an Authentication Server Function (AUSF), a Session Management Function (SMF), an Application Function (AF), an Unified Data Function (UDM), and a Policy control function (PCF).

(A9) In any one of the methods denoted as (A1) through (A8), the local data may include content data from a content server at the second client node.

(A10) The method denoted as (A9) may further include instantiating the content server in customer premises equipment at the second client node.

(A11) The method denoted as (A10) may further include instantiating the content server in the customer premises equipment in response to a demand for the data by one or more client nodes communicatively coupled to the first communication medium.

(A12) Any one of the methods denoted as (A1) through (A11) may further include transmitting the remote data between the first client node and the network hub partially using a backhaul communication medium between the first shared communication medium and the network hub.

(A13) In any one of the methods denoted as (A1) through (A12), the first shared communication medium may include a coaxial electrical cable.

(A14) In any one of the methods denoted as (A1) through (A13), the first shared communication medium may include an optical cable.

(B1) A method for transmitting data in a communication network including a shared communication medium may include (1) generating, at a first client node connected to a first shared communication medium, a list of other client nodes accessible to the first client node via the first shared communication medium, (2) identifying, at the first client node, a selected client node from the list of other client nodes, where the selected client node offers a first network resource required at the first client node, (3) accessing, at the first client node, the first network resource from the selected client node using the first shared communication medium, and (4) accessing, at the first client node, a second network resource via a network hub remote from the first client node, using the first shared communication medium.

(B2) In the method denoted as (B1), the first network resource may be a wireless communication network control module in customer premises equipment at the selected client node.

(B3) In the method denoted as (B2), the wireless communication network control module may include at least one of a Mobility Management Entity (MME), a Serving Gateway (S-GW), a Home Subscriber Server (HSS), a PDN Gateway (P-GW), a Policy Control and Charging Rules Function (PCRF), a User Plane Function (UPF), an Access Management Mobility Function (AMF), an Authentication Server Function (AUSF), a Session Management Function (SMF), an Application Function (AF), an Unified Data Function (UDM), and a Policy control function (PCF).

(B4) In the method denoted as (B1), the first network resource may be a content server in customer premises equipment at the selected client node.

(B5) In any one of the methods denoted as (B1) through (B4), the first shared communication medium may include a coaxial electrical cable.

(B6) In any one of the methods denoted as (B1) through (B5), the first shared communication medium may include an optical cable.

Changes may be made in the above methods, devices, and systems without departing from the scope hereof. It should thus be noted that the matter contained in the above description and shown in the accompanying drawings should be interpreted as illustrative and not in a limiting sense. The following claims are intended to cover generic and specific features described herein, as well as all statements of the scope of the present method and system, which, as a matter of language, might be said to fall therebetween.

What is claimed is:

1. A method for transmitting data in a communication network including a shared communication medium, comprising:

transmitting local data between a first node and a second node according to a first data protocol, using a first shared communication medium including at least one of an electrical cable and an optical cable;

transmitting remote data between the first node and a network hub according to a second data protocol different from the first data protocol, using at least the first shared communication medium;

determining that a network resource required at the first node is not available to the first node via another node communicatively coupled to the first shared communication medium; and

in response to determining that the network resource is not available to the first node via another node communicatively coupled to the first shared communication medium, accessing the network resource via the network hub.

2. The method of claim **1**, further comprising simultaneously (a) transmitting the local data between the first node and the second node via one or more first frequency bands using the first shared communication medium and (b) transmitting the remote data between the first node and the network hub via one or more second frequency bands using at least the first shared communication medium, the one or more first frequency bands being different from the one or more second frequency bands.

3. A method for transmitting data in a communication network including a shared communication medium, comprising:

transmitting local data between a first node and a second node according to a first data protocol, using a first shared communication medium including at least one of an electrical cable and an optical cable;

transmitting remote data between the first node and a network hub according to a second data protocol different from the first data protocol, using at least the first shared communication medium;

determining that a network resource required at the first node is available at the second node; and

in response to determining that the network resource is available at the second node, accessing the network resource at the first node from the second node using the first shared communication medium.

4. A method for transmitting data in a communication network including a shared communication medium, comprising:

transmitting local data between a first node and a second node according to a first data protocol, using a first shared communication medium including at least one of an electrical cable and an optical cable, the local data comprising wireless communication network control data transmitted between a wireless base station at the first node and a wireless communication network control module at the second node;

transmitting remote data between the first node and a network hub according to a second data protocol different from the first data protocol, using at least the first shared communication medium; and

instantiating the wireless communication network control module in customer premises equipment at the second node.

5. The method of claim **4**, further comprising instantiating the wireless communication network control module in the customer premises equipment in response to a change in operating conditions in the wireless communication network.

6. The method of claim **4**, wherein the wireless communication network control module comprises at least one of a Mobility Management Entity (MME), a Serving Gateway (S-GW), a Home Subscriber Server (HSS), a PDN Gateway (P-GW), a Policy Control and Charging Rules Function (PCRF), a User Plane Function (UPF), an Access Management Mobility Function (AMF), an Authentication Server

Function (AUSF), a Session Management Function (SMF), an Application Function (AF), an Unified Data Function (UDM), and a Policy control function (PCF).

7. A method for transmitting data in a communication network including a shared communication medium, comprising

transmitting local data between a first node and a second node according to a first data protocol, using a first shared communication medium including at least one of an electrical cable and an optical cable, wherein the local data comprises content data from a content server at the second node;

transmitting remote data between the first node and a network hub according to a second data protocol different from the first data protocol, using at least the first shared communication medium;

instantiating the content server in customer premises equipment at the second node in response to a demand for the data by one or more nodes communicatively coupled to the first shared communication medium.

8. The method of claim **1**, further comprising transmitting the remote data between the first node and the network hub using a backhaul communication medium between the first shared communication medium and the network hub.

9. The method of claim **1**, wherein the first shared communication medium comprises a coaxial electrical cable.

10. A node for use in a communication network including a shared communication medium, comprising:

a first communication module configured to transmit local data between the node and an additional node according to a first data protocol, using a first shared communication medium including at least one of an electrical cable and an optical cable;

a second communication module configured to transmit remote data between the node and a network hub according to a second data protocol that is different from the first data protocol, using the first shared communication medium; and

a processor and a memory, wherein the processor is configured to execute instructions stored in the memory to:

determine that a network resource required at the node is not available via another node communicatively coupled to the first shared communication medium, and

in response to determining that the network resource is not available via another node communicatively coupled to the first shared communication medium, access the network resource via the network hub.

11. The node of claim **10**, wherein the first and second communication modules are further respectively configured to (a) transmit the local data between the node and the additional node via one or more first frequency bands using the first shared communication medium and (b) transmit the remote data between the node and the network hub via one or more second frequency bands using at least the first shared communication medium, the one or more first frequency bands being different from the one or more second frequency bands.

12. A node for use in a communication network including a shared communication medium, comprising:

a first communication module configured to transmit local data between the node and an additional node according to a first data protocol, using a first shared communication medium including at least one of an electrical cable and an optical cable;

a second communication module configured to transmit remote data between the node and a network hub according to a second data protocol that is different from the first data protocol, using the first shared communication medium; and

a processor and a memory, wherein the processor is configured to execute instructions stored in the memory to:

determine that a network resource required at the node is available at the additional node, and

in response to determining that the network resource is available at the additional node, access the network resource from the additional node using the first shared communication medium.

13. The node of claim **10**, further comprising a wireless communication network control module for controlling one or more wireless base stations communicatively coupled to the first shared communication medium.

14. The node of claim **10**, further comprising a content server for providing content to one or more other nodes communicatively coupled to the first shared communication medium.

15. The node of claim **12**, further comprising a wireless communication network control module for controlling one or more wireless base stations communicatively coupled to the first shared communication medium.

16. The node of claim **12**, further comprising a content server for providing content to one or more other nodes communicatively coupled to the first shared communication medium.

17. The method of claim **3**, further comprising transmitting the remote data between the first node and the network hub using a backhaul communication medium between the first shared communication medium and the network hub.

18. The method of claim **3**, wherein the first shared communication medium comprises a coaxial electrical cable.

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